An Overview of the Center of Excellence for Risk-Based Community Resilience Planning

Bruce R. Ellingwood, Ph.D., P.E., N.A.E
Co-Director, Center for Risk-based Community Resilience Planning
Colorado State University

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Urban infrastructure

- Natural hazards
- Manmade hazards
- Degradation
- Climate change

- Performance Goals
- Mitigation
- Response
- Recovery

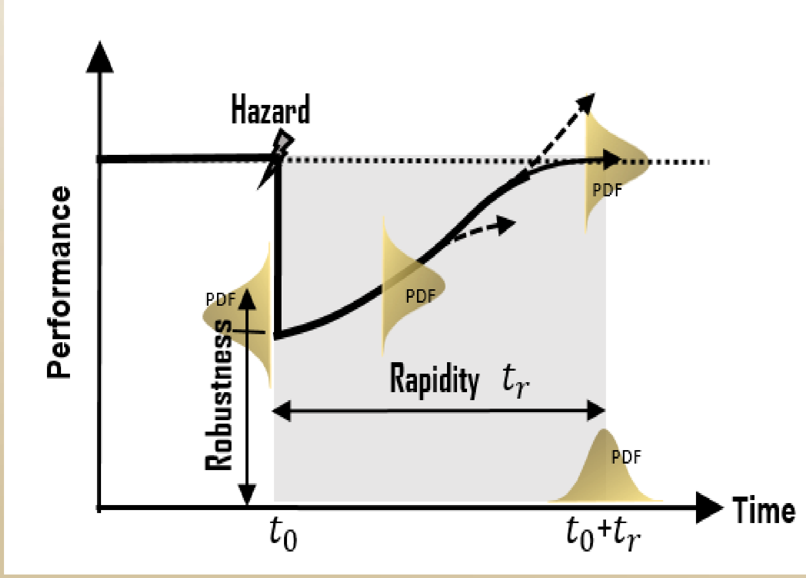
Traditional approaches to risk management of the built environment

A critical appraisal

- Standards-based, with a focus on individual hazards and facilities
- Measures of performance among interdependent systems are inconsistent
- Margins of safety and functionality are not commensurate with uncertainty
- Critical social institutions are not considered
- Risks may not be properly priced by insurance, financial institutions and government

What is community resilience, and how do we model it?

"The ability of a community to prepare for and adapt to changing conditions and to withstand and recover from disruptions to its physical and non-physical infrastructure."



Why is community resilience important?

"To prevent a hazard from becoming a disaster"

- Recent disasters have revealed shortcomings in building practices that focus on performance of individual facilities.
- Populations and economic development are shifting to hazard-prone areas.
- Public/private investments in infrastructure renewal are limited
- Global climate change may impact frequency/severity of environmental events

Community resilience questions

- How can community leaders know how resilient their community is?
- How can they know if their decisions and investments to improve resilience are making a significant difference?
- How can they deal with uncertainty and risk?

Introducing the Center

- Development of measurement science and technology to understand what makes a community resilient
- Physics-based models of interdependent and cascading hazards and their effect on the built environment
- Standardized data ontologies
- Modeling and integration of socio-economic support systems and their interfaces with physical infrastructure systems.
- Resilience-based performance criteria and metrics.
- Decision support systems with intelligent learning algorithms

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University of Washington
Oregon State University OSU
Rice
Texas A&M University
The University of Oklahoma
USA
Texas A&M University Kingsville
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National Center for Supercomputing Applications

Center Objective

Measurement science to understand what makes a community resilient

- **Approximately 40 projects in three thrusts**
  - **Thrust 1**: A multidisciplinary computational environment with fully integrated supporting databases (**IN-CORE**: Interdependent Networked COmmunity REsilience Modeling Environment)
  - **Thrust 2**: Standardized data ontologies, robust data architecture, and effective database management tools to support risk-informed decision-making
  - **Thrust 3**: Validation studies to test the data collection process and its integration. Risk-informed intelligent search and decision algorithms

Testbed Problems

Seaside, OR (Earthquake and Tsunami)

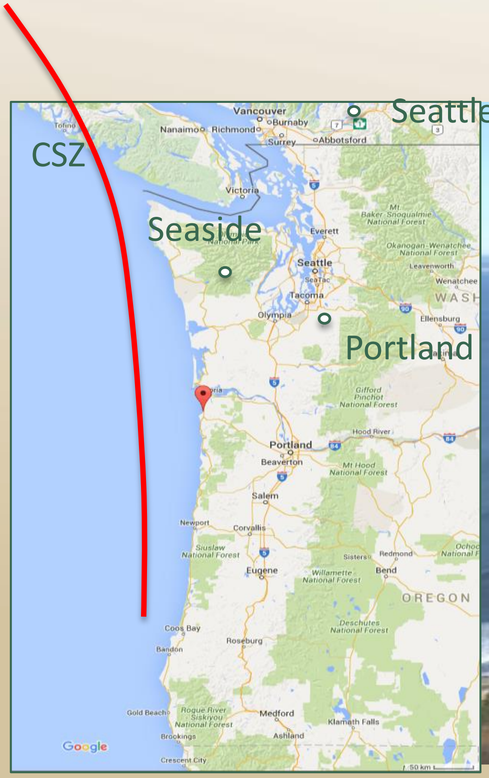
Shelby County, TN (Riverine Flood, climate change)

Centerville Virtual Community (Earthquake and Tornado)

Joplin, MO tornado (May 22, 2011) Hindcast

Galveston, TX Hurricane Ike (Sept 1, 2008) Hindcast

Seaside,OR


CSZ
Seattle
Seaside
Portland
Vancouver
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Seattle
Tacoma
Olympia
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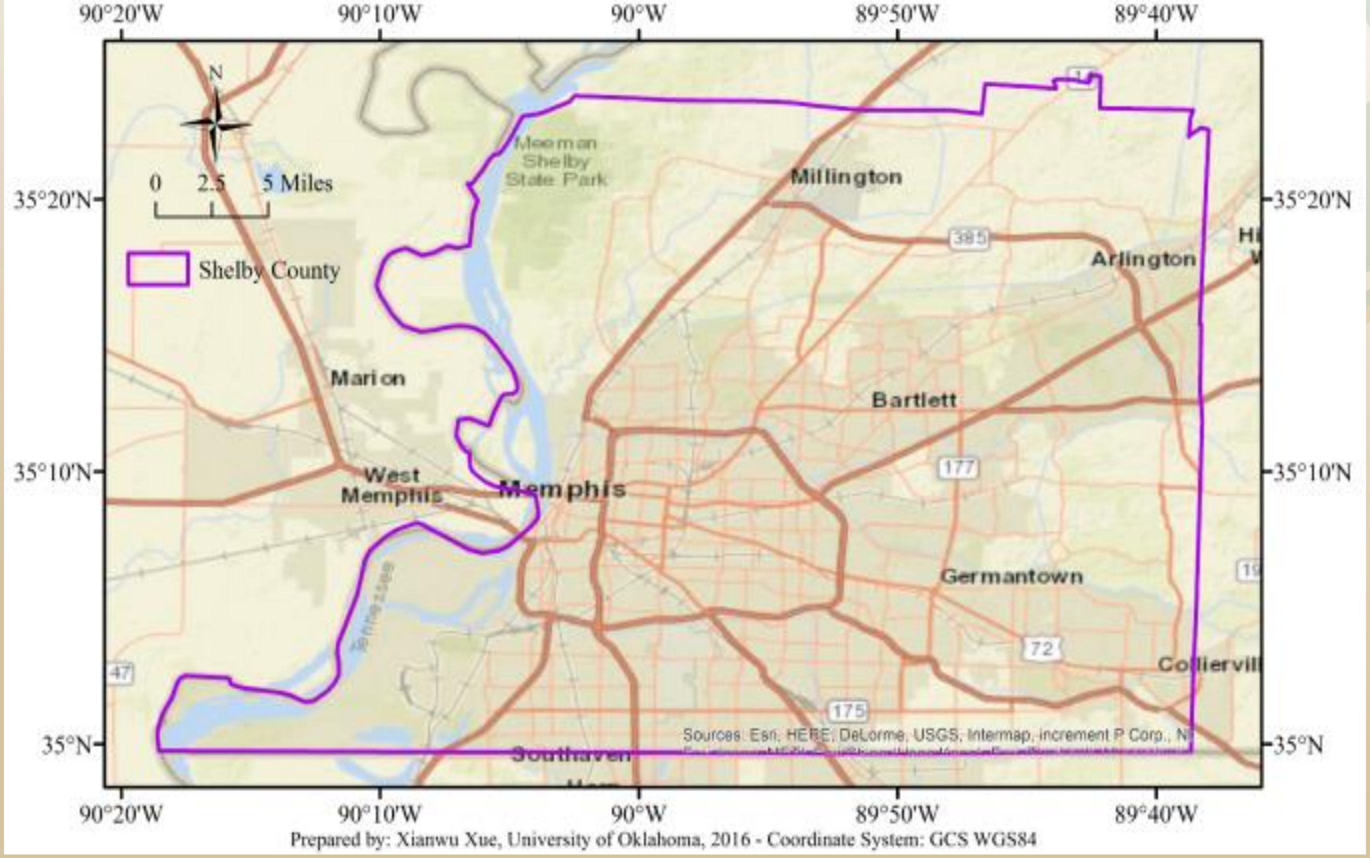
Shelby County, TN



The Centerville Testbed

Motivation

- A simple community model with essential physical, social and economic infrastructure components and systems enables their algorithmic linkages and interdependencies to be developed, tested and verified independently by simple independent calculations, experience or intuition.

- Software developers at NCSA require prototypical algorithms and datasets so that they can begin coding IN-CORE modules while awaiting more realistic and complex algorithms and datasets to emerge in the project out-years.

- The common community model requires engineers, economists and sociologists to begin working together immediately, something that rarely happens in large interdisciplinary projects.

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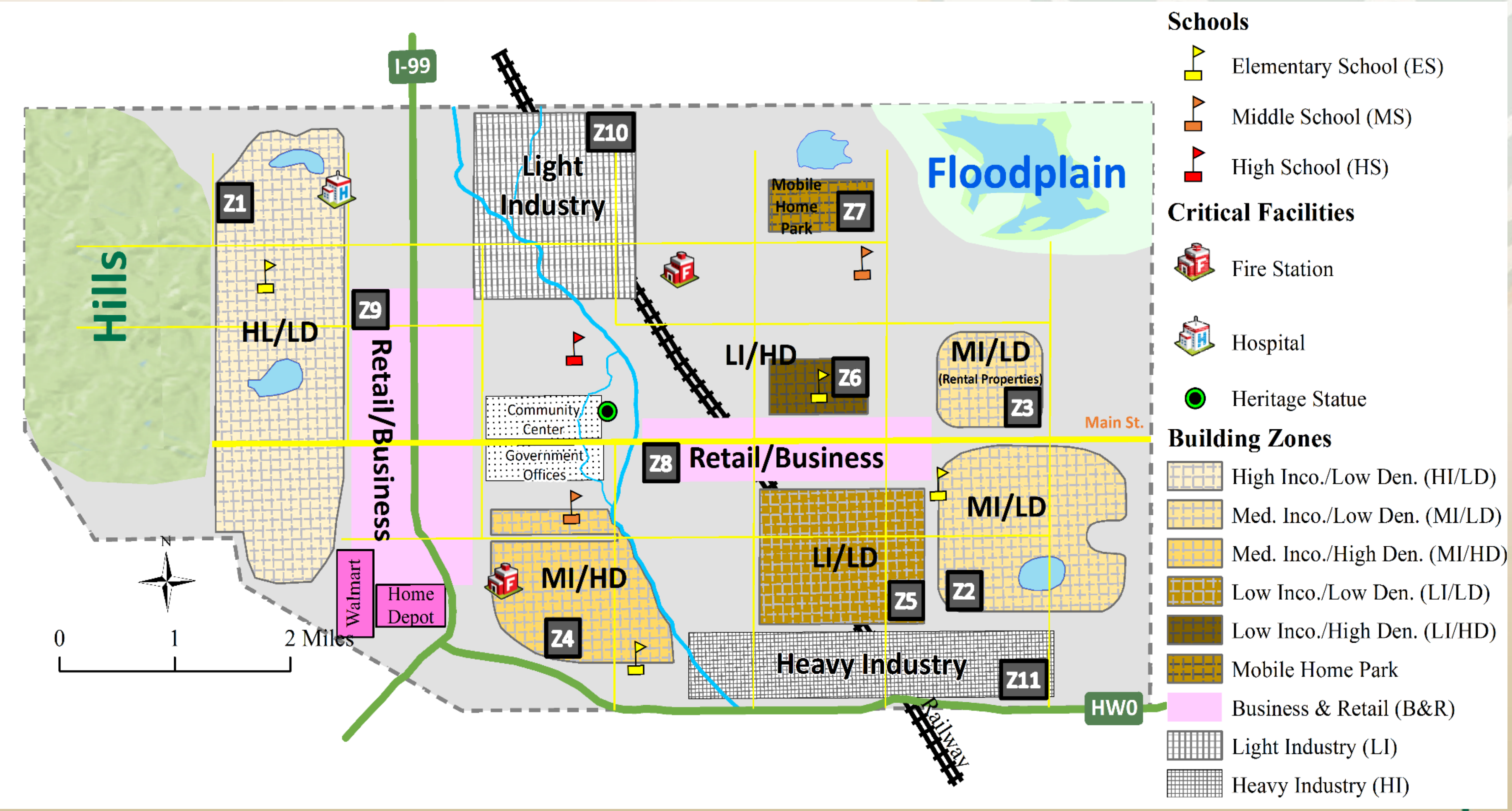
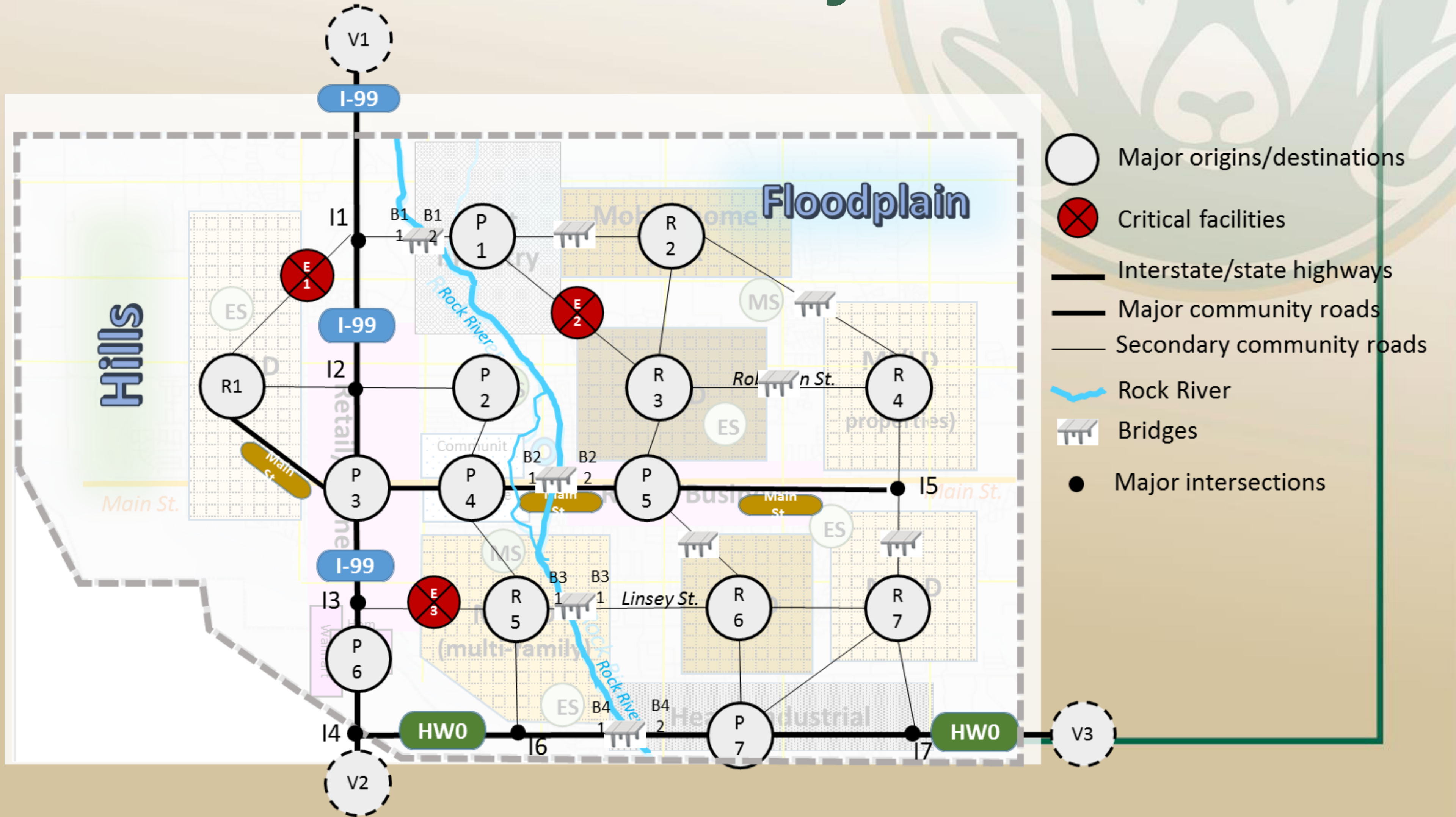
Infrastructure systems supporting community resilience

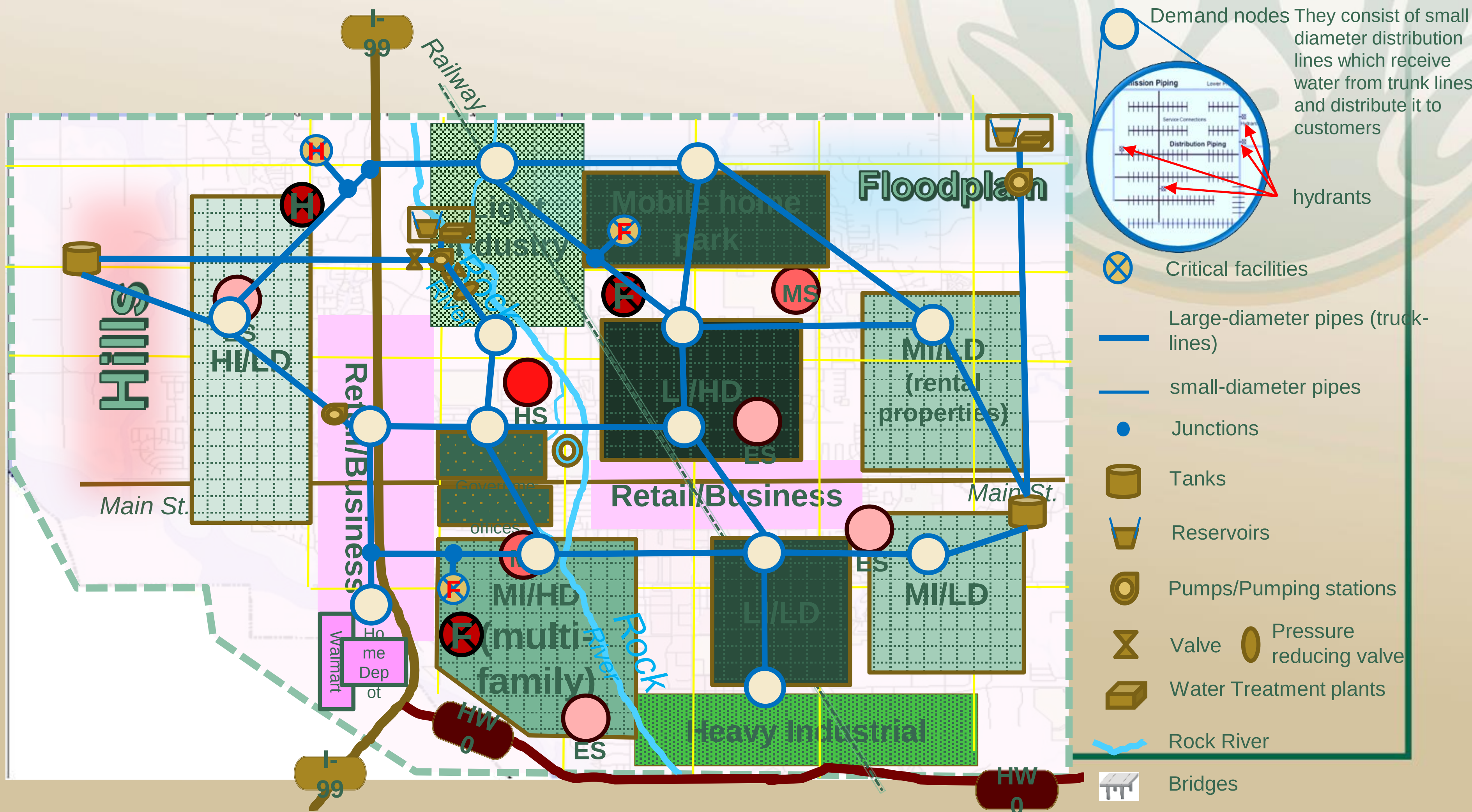
- Physical systems representing distinct topologies
  - Buildings
  - Transportation, water, electrical power
- Economic systems
- Social systems


I-99
Z10
Light Industry
Mobile Home Park
Z7
Floodplain
Z1
Hills
HL/LD
Z9
Retail/Business
LI/HD
Z6
MI/LD
(Rental Properties)
Z3
Main St.
Community Center
Government Offices
Z8
Retail/Business
MI/LD
LI/LD
MI/HD
Walmart
Home Depot
Z4
Z5
Z2
Heavy Industry
Z11
HW0
Railway
N
0
1
2 Miles
Schools
Elementary School (ES)
Middle School (MS)
High School (HS)
Critical Facilities
Fire Station
Hospital
Heritage Statue
Building Zones
High Inco./Low Den. (HI/LD)
Med. Inco./Low Den. (MI/LD)
Med. Inco./High Den. (MI/HD)
Low Inco./Low Den. (LI/LD)
Low Inco./High Den. (LI/HD)
Mobile Home Park
Business & Retail (B&R)
Light Industry (LI)
Heavy Industry (HI)

Centerville roadway network



Water Network – Centerville



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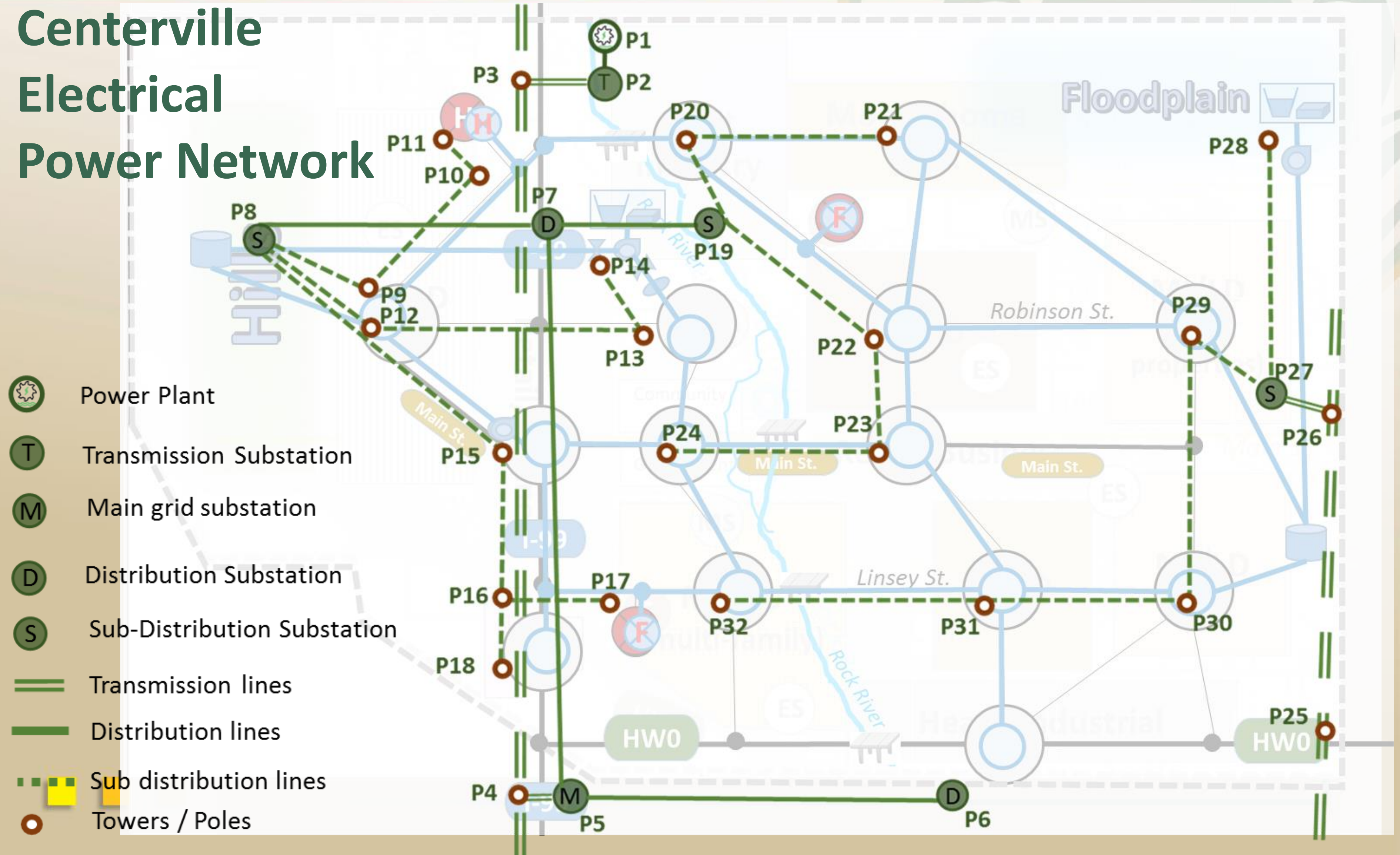
Centerville Electrical Power Network



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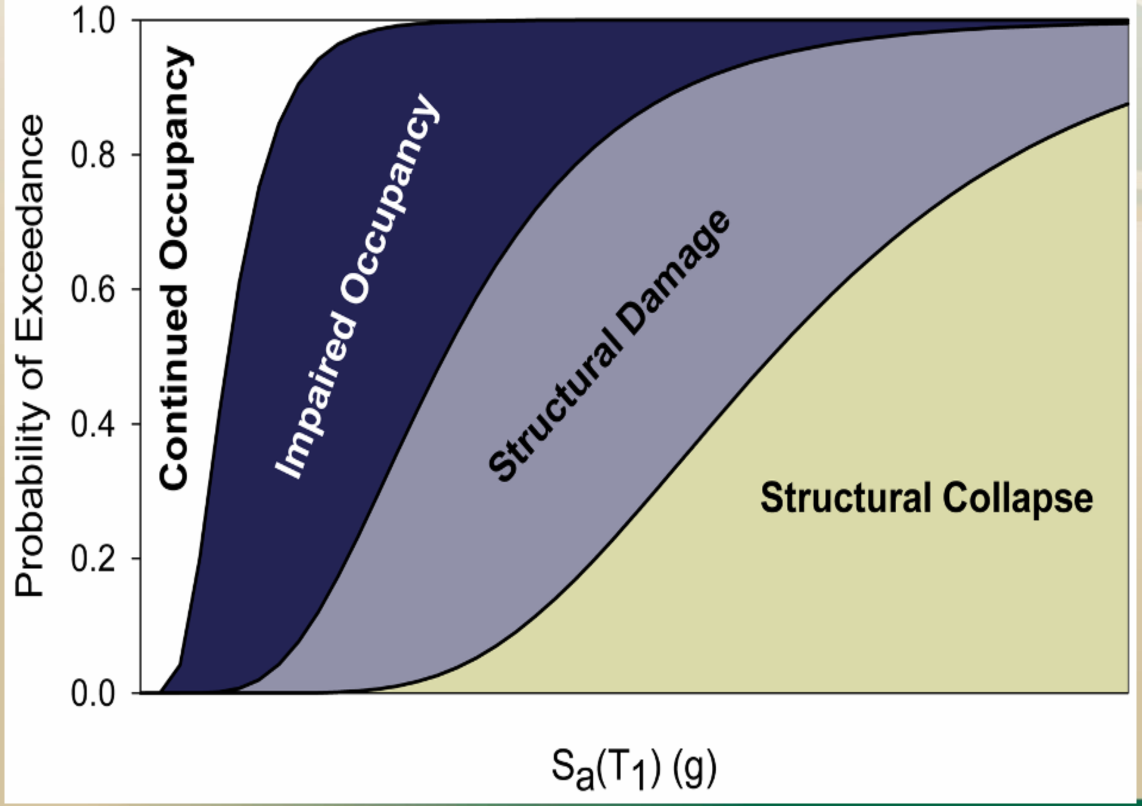
Integration of physical, social and economic models

- Scenario earthquake (M_w = 7.8, R = 40 km)
- Building damage and loss
- Social and economic impact
- Decision analysis

Damage state probabilities



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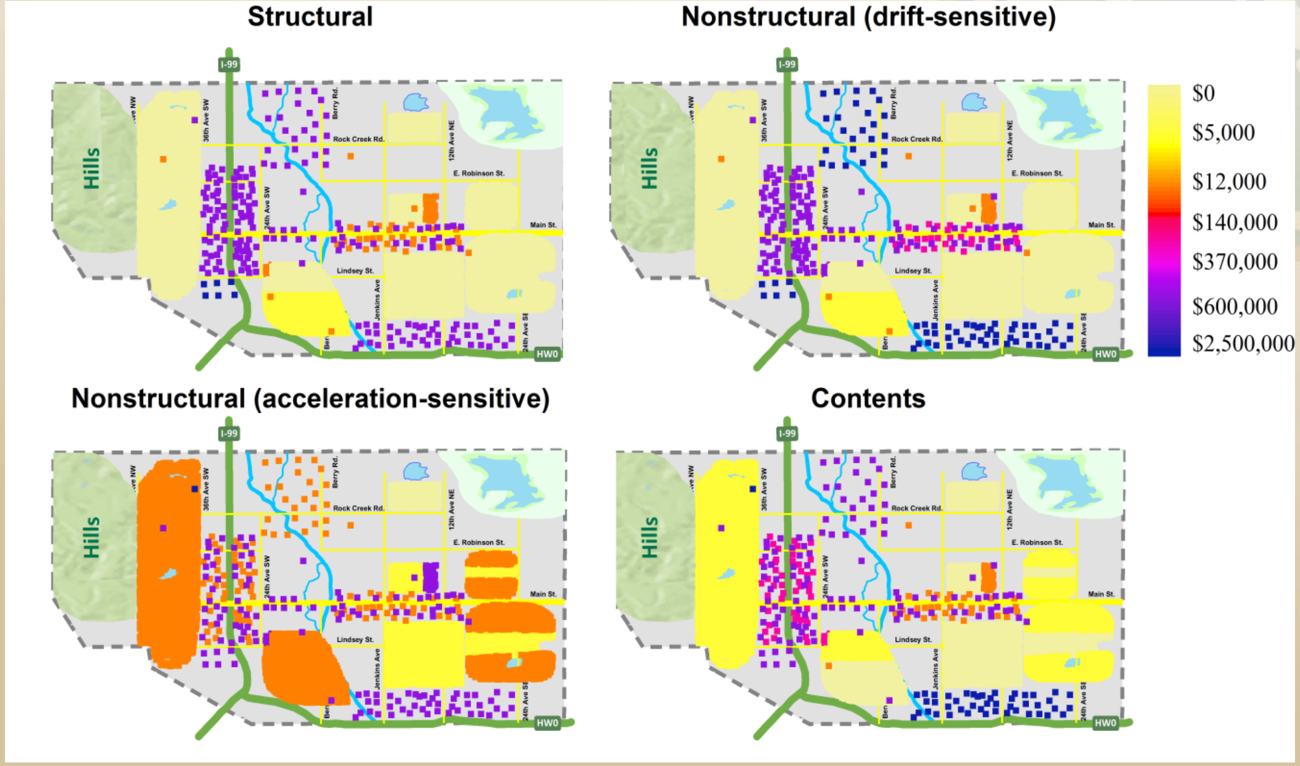
Expected direct losses



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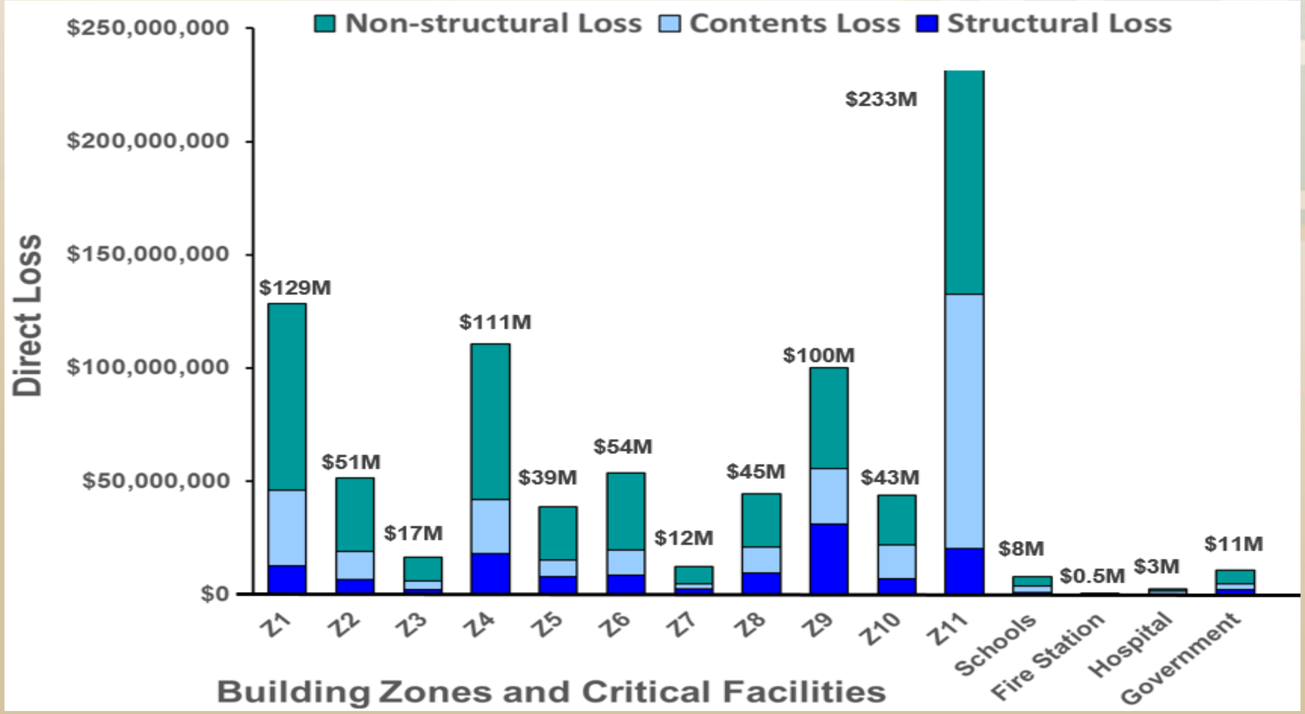
Expected loss by zone



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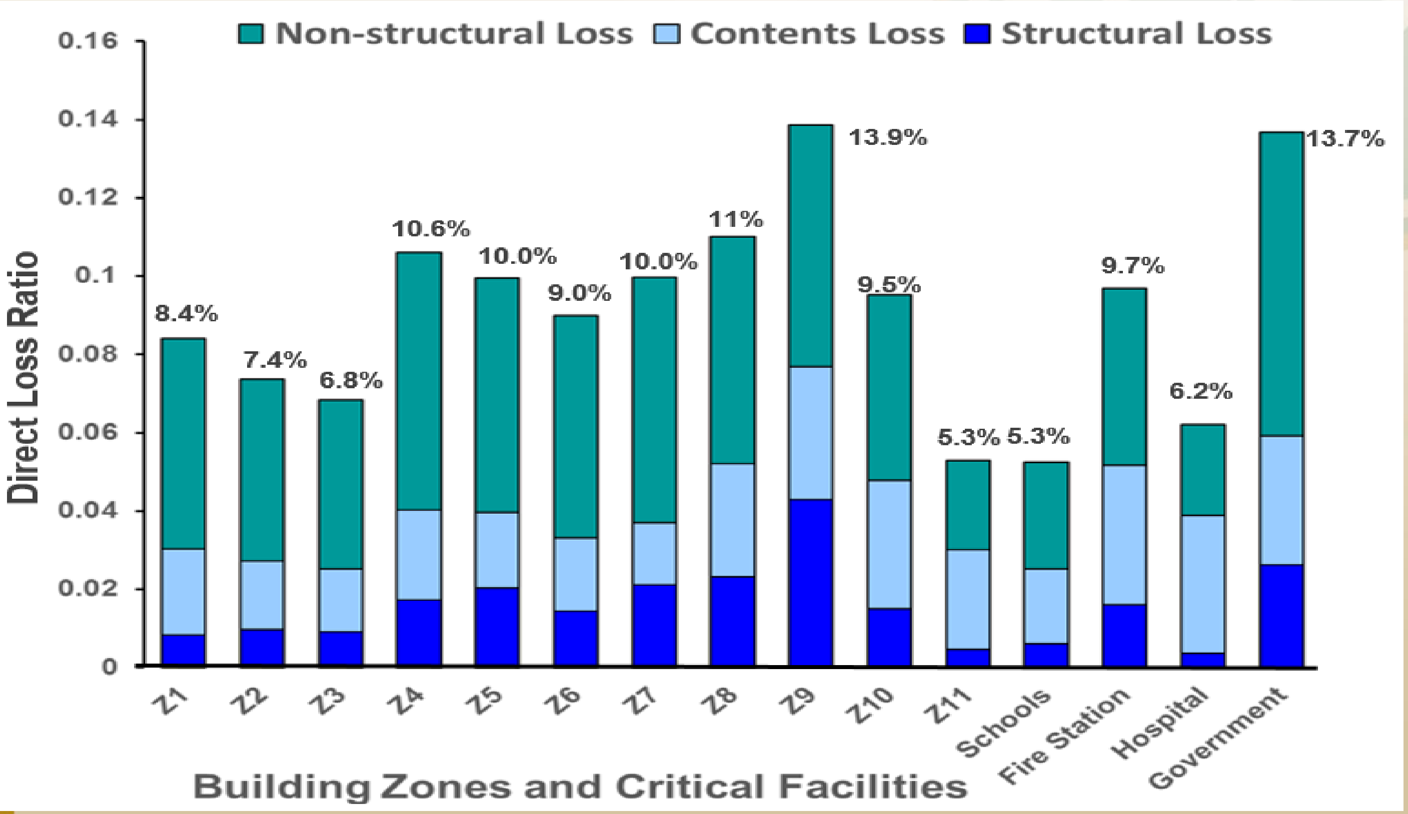
Expected loss *ratio* by zone



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Mitigation resource allocation

Allocate limited resources to retrofit building types in each zone, to specific code levels with respect to the following competing objectives:

- Minimize economic loss (i.e., structure, non-structure, and contents loss, provided by the engineering team)
- Minimize total dislocation (OLS model provided by the Social Science team)

Constraint:

- Overall disparity in the dislocation rates by socio-economic status does not increase

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Current social and economic metrics

- Losses due to direct damages
- Population dislocation
- Employment/domestic output
- Level and distribution of household income

Community resilience panel for buildings and infrastructure systems

Areas of CRP-CoE collaboration

- Hazard scenarios
- Physical and socioeconomic infrastructure models
- Key social institutions and their connectivity
- Key performance metrics
- Decision makers and decision support
- Practical constraints on community function recovery
- Alignment of IN-CORE products with NIST's *Community Resilience Planning Guide* and *Economic Decision Guide*
- Review of recommendations for enhancing community resilience
- Communicating performance/risk to community stakeholders

Community resilience metrics

A cautionary note

- Measurement science requires performance measures and metrics that can be quantified unambiguously.
- The assessment that “moderate damage” is equivalent to “permanent drift of 10 inches in the lateral force-resisting system has occurred” is a value judgment. The Center is providing the science for decision-makers to draw such conclusions, but value judgments are not within our scope.
- Identifying performance levels and quantifying them are equally important

Current center research thrusts

- Multiple hazards – individual, cascading, competing, including impact of climate change
- Community infrastructure models
- Fully integrated interdependent physical/social/economic systems analysis
- Recovery modeling
- Testbeds and hindcasts
- Field study protocols
- Decision support algorithms and practical decision tools

Thank you

http://resilience.colostate.edu

resilience@colostate.edu

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